APPLICATION FOR
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FOR

SYSTEM FOR CONVEYING AND SLICING

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BACKGROUND

1. Technical Field

The present invention relates to a system for processing food items to form slices. More specifically, this invention relates to hydraulically transporting food items with the use of an eductor, reducing the size of large items using a segmented cutter, maximizing cutting efficiency by controlling velocities and mass flow rates, slicing food items with a transverse slicer, controlling slicing velocities to optimize performance, and controllably spreading the resulting slices upon a conveyor for further processing.

2. Description of Related Art

The commercial process of processing produce such as vegetables, tubers, nuts, and fruit requires sized reduction of large volumes of food stuffs. The present invention will be described in terms of transporting and slicing potatoes to make potato chips. However, as those skilled in the art will appreciate, the present invention can be employed for a wide variety of uses other than making potato chips.

Prior art industrial-sized potato slicing systems typically use centrifugal slicers to cut potatoes into slices, which can be used to make products such as potato chips, or dishes such as scalloped potatoes and au gratin potatoes. A centrifugal slicer, such as the Urschel Model Continuous Cut ("CC") Slicer, manufactured by Urschel Laboratories, Inc., comprises several upright blades arranged in a ring around a central impeller or rotary disk. Figure 6 of U.S. Patent No. 5,694,824, granted to Jacko et al., for example, shows one such prior art centrifugal slicer. As potatoes are fed into the slicer, the rotating

impeller or disk initially throws potatoes against the blades and then pushes the potatoes across the blades, thereby shaving slices from the potatoes.

Centrifugal-type slicers, however, have several drawbacks. One such drawback is reduced yield due to high slicing velocities. In order for centrifugal slicers to work properly, a minimum amount of rotational speed is required to create the centrifugal force necessary to force the potatoes against the cutting surfaces. As a result of the relatively high slicing and impact speeds, centrifugal slicers (or cutters) generally produce a considerable amount of waste and scrap. For example, a potato can be damaged when it is thrown against the slicer walls between blades, as well as when a blade merely nicks the surface but fails to remove a slice. Furthermore, the high slicing speeds cause a significant amount of potato cell damage. A potato's starch-containing cells are viscoelastic, which means that the more quickly pressure is applied during slicing, the more brittle the cell walls become. Thus, the number of potato cells damaged per slice increases as the slicing speed increases. When potato cells break, the contained starch is released, resulting in reduced product yield. As much as 16% by weight of the potato feed can be lost to waste, scraps, and cell damage when using centrifugal slicers.

A second drawback of centrifugal-type slicers is the undesirable level of cracking that such slicers can impart in the slices. Because the viscoelastic potato cells become more brittle with increased blade impact speed, the slices become more likely to crack as the impact speed increases. Such cracking undesirably increases the occurrence of slice fold-overs and the amount of oil-uptake.

In addition, centrifugal slicers can only accommodate round chipping potatoes and cannot accommodate large elongated potatoes. Elongated potatoes tend to plug

centrifugal slicers. Elongated potatoes also tend to lay sideways in such slicers, which undesirably increases variability in slice thickness. Moreover, centrifugal slicers create undesirably shaped, oblong potato chips when supplied with normal elongated potatoes. **Figures 1a** and **1b** show examples of slices produced when a centrifugal slicer is supplied with a round potato **110** versus an elongated potato **140**. A centrifugal slicer will slice a round chipping potato **110** into round slices with ridges **130** or without ridges **120**, depending upon whether the slicer's blade edges are corrugated. In contrast, a centrifugal slicer will slice an elongated potato **140** lengthwise into oblong slices with or without ridges **160**, **150**, depending on whether the blade edges are corrugated. While some variation in slice or chip shape is acceptable, slices or chips having extreme aspect ratios (ratio of length to width) may be undesirable in some circumstances. Thus, elongated potatoes are generally not used in centrifugal slicers because of the potentially undesirable oblong-shaped slices they produce.

Although several non-centrifugal-type cutters exist for processing potatoes, few of them relate specifically to creating potato slices suitable for products such as potato chips. For example, U.S. Patents Nos. 5,394,793, and 5,343,791, granted to Julian et. al., disclose rotating cutting head assemblies for cutting singular potatoes into helical strips. As the spiral cutting heads rotate, they make continuous helical bores through singular potatoes, thus making helical strips. The devices disclosed in the '793 and '791 patents, however, are not suitable for cutting potato slices.

A few potato slicer systems use horizontal discs with blades to slice potatoes. For example, U.S. Patent No. 4,706,556, granted to Wallace et al., discloses a horizontal slicing disc with an inclined potato feeding tube. Wallace et al. teach that the potatoes

must be individually removed from a washer drum and deposited into the slicer's feed tube. Prior to the current invention, however, there has been no automated slicing system for maximizing cutting efficiency and product yield. More specifically, there has been no automated system for controlling the feed rate of the potatoes to a transverse slicer and slicing the potatoes at an automatically controlled and reduced slicing speed.

Many prior-art slicing systems transport potatoes from one place to another by propelling them with an impeller-type food pump such as the Single Port Impeller Pump manufactured by the Cornell Pump Company. A significant number of the potatoes, however, are damaged as the potatoes travel through the pump and are struck by the rotating impeller. Furthermore, impeller-type food pumps draw a significant amount of energy and can therefore be expensive to operate. The cost of periodically replacing the impellers due to wear and tear also adds to the operating and maintenance costs. Other slicing systems, with the use of a venturi, accelerate a flow of solid food items and water through a set of stationary blades. For example, U.S. Patent No. 5,390,590, granted to Mendenhall, discloses both concepts. Mendenhall discloses a hydraulic cutter in which a centrifugal food pump sends potatoes and water through a venturi tube, which in turn accelerates the potatoes through a grid of stationary blades. Slicing systems such as that disclosed in Mendenhall, however, relate to processes for making french fries and are not suitable for making potato chips or other products using potato slices. Prior to this invention, few potato slicing systems have used an eductor/venturi system to gently transport potatoes in a non-destructive manner throughout a process for making slices. Furthermore, no prior art slicing system has used a plurality of diverters to divide a stream of food items into several independently controlled streams, gently fed such food

items into and propelled such streams through a manifold of several independently controlled eductors.

Prior art potato processing systems use potato halvers, such as Grove Dale Corporation's Auto Halver, to reduce the size of potatoes that are too large for processing. These potato halvers cut potatoes cross-wise along the short axis to reduce the overall length of oversized potatoes by half. Such halvers, however, are not suitable in potato slicing systems in which potatoes are cut into transverse slices, since such cutters do not reduce the diameter of potato pieces in the minor dimension.

Another problem encountered with prior art methods and devices is that the resulting potato slices often undesirably clump together as they exit the slicers and are moved downstream for further processing. Slice clumping prevents the slices from being evenly distributed upon a conveyor. Slice clumping also hinders the slices from being properly baked, toasted, or fried.

Resulting potato slices often contain slicing scraps, loose starch and other undesirable fines that are desirably removed from the slices before further processing. Prior art slicing systems typically remove loose starch, slicing scraps and fines by transporting slices to, and processing them through, a separate washing unit. Thus, there is a need for a simplified method for removing loose starch and slicing scraps.

Consequently, a need exists for a food processing system that can slice food items such as potatoes with less waste and scrap, as well as accommodate a wider variety of food shapes. More specifically, such a system should process potatoes with a relatively slower slicing speed and accommodate both round and oblong potatoes by slicing potatoes transversely. Such a system should also reduce oversized potatoes by slicing

them lengthwise into smaller-diameter segments. The novel system should transport potatoes and potato segments in a flume of fluid towards at least one slicer with the use of an eductor/venturi system that gently propels potatoes in a non-destructive manner. Once cut, the system should transport the slices in a flume of fluid for further processing. Such a flume of fluid should also wash away loose starch, remove slicing scraps and remove undesirable fines from the slices. In addition, such a slicing system should prevent slice clumping and controllably distribute slices upon a conveyor leading to the next processing unit operation. Such a system should preferably be automated, but it should also be amenable to manual operation if desired.

SUMMARY OF THE INVENTION

In accordance with one embodiment of the present invention, the food processing system comprises an oversized-product separator, a segmented cutter, a mass-flow/spreading conveyor, a diverter stage, an eductor stage, a dewatering stage, a starch and fines removal stage, a slicer infeed conveyor, at least one slicer, and a slice spreader. In a preferred embodiment, potatoes and potato slices are transferred quickly and gently using flumes of fluid, potato slices are gently washed while being transferred, and cutting losses are decreased by minimizing slicing speeds.

In a preferred embodiment, an oversized-product separator separates oversized potatoes from a potato feed to ensure that the oversized potatoes will not jam the feed tubes of downstream potato slicers. A segmented cutter reduces the diameter of oversized potatoes by forcing such potatoes through a set of blades. Acceptably sized potatoes exiting the oversized-product separator then pass through a mass-flow/spreading conveyor before being divided into two or more lanes in a diverter stage. Weigh conveyors (or load cells) are used to regulate the mass flow rate of potatoes in the mass-flow/spreading conveyor in order to help maintain a constant mass flow rate for mass-flow-rate sensitive units downstream, such as a frying unit.

After the mass-flow/spreading conveyor, the potatoes then enter a diverter stage to be divided into two or more potato streams. At least one diverter, or movable divider, divides the flow of potatoes into two or more streams of potatoes. Thereafter, the streams of potatoes are kept apart by stationary dividers, separate channels, pipes, or conveyors, and each stream of potatoes is lead into an eductor stage where the potatoes are propelled further downstream.

Each eductor in the eductor stage comprises a fluid jet pump that accelerates a fluid flow through a narrowing section of a pipe or channel, to which a product in-feed line is also connected. Each stream of potatoes is propelled along this stream of water ("eductor flume") from the eductor stage to a dewatering stage, which is typically located fairly close to a corresponding slicer. Because each stream of potatoes is isolated from the other streams and is propelled by its own eductor, each stream can be independently controlled. Furthermore, each eductor can be independently controlled to vary the properties of each diverted stream even though each flume may originate from a common supply of water that is propelled by a single, common pump.

Once the potatoes have been dewatered, the slicer infeed conveyor feeds the potatoes into each slicer. Sensors positioned over the slicer infeed conveyors measure the individual potato velocities and the duty cycles of at least one lane of potatoes leading into each slicer.

The potatoes are then fed into transverse slicers, and the RPM set point of each slicer is adjusted to the minimum rate necessary to process the flow of potatoes. The slices exiting the slicers are transported along a flume of water into a slice spreader, which controllably distributes the slices onto a dewatering conveyor for further processing. In addition to serving as a medium within which the slices are transported, the flume of water also washes the starch, fines and other scrap material from the slices. Upon being discharged from the slice spreader, the dewatering conveyor lifts the washed slices away from the flume/wash water.

A starch removal unit can be used to remove any starch, fines and other particles entrained in the water used throughout the system, and the purified water can be recycled.

The above as well as additional features and advantages of the present invention will become apparent in the following written detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objectives and advantages thereof, will be best understood by reference to the following detailed description of illustrative embodiments when read in conjunction with the accompanying drawings, wherein:

Figures 1a and **1b** are top side views of examples of slices produced when a centrifugal slicer is supplied with a round potato versus an oblong potato;

Figure 2 is a perspective view of one embodiment of a transverse slicer suitable for use with the present invention's system for processing potatoes;

Figure 3 is a side cross-sectional view of the transverse slicer shown in **Figure 2**;

Figures 4a and **4b** are top side views of examples of slices produced when a transverse slicer is supplied with either a round potato or an oblong potato;

Figure 5 is a flow chart of a slicing system having one or more slicers in accordance with one embodiment of the present invention;

Figure 6 is a perspective view of an oversized-product separator in accordance with one embodiment of the present invention;

Figures 7a and **7b** are, respectively, a front elevational view and a side elevational view of an oblong potato being cut by a tri-blade segmented cutter having curved blades that radiate from a shared center, in accordance with a preferred embodiment;

Figures 7c and **7d** are, respectively, a front elevational view and a perspective view of an oblong potato being cut by a tri-blade segmented cutter having straight blades that radiate from a shared center, in accordance with one embodiment;

Figures 7e and **7f** are, respectively, a front elevational view and a perspective view of an oblong potato being cut by a prior art potato halver;

Figures 7g and **7h** are, respectively, a front elevational view and a perspective view of an oblong potato being cut by a segmented cutter having a single straight blade in accordance with one embodiment;

Figure 8a is a side cross-sectional view of a diverter stage and an eductor stage in accordance with a preferred embodiment of the invention;

Figure 8b is a front cross-sectional view of the diverter stage shown in **Figure 8a**;

Figure 8c is a front cross-sectional view of one diverter of the diverter stage shown in **Figure 8a**;

Figure 8d is a perspective view of several positioning carriages, one for each diverter, in accordance with a preferred embodiment;

Figure 9 is a side cross-sectional view of another embodiment of an eductor;

Figure 10a is a perspective view of a dewatering stage and a slicer infeed conveyor having two separate sections in accordance with one embodiment of the present invention;

Figure 10b is a perspective view of a dewatering stage and a unitary slicer infeed conveyor in accordance with one embodiment of the present invention;

Figures 11a and **11b** are respectively a side elevational view and a perspective view of a slicer spreader in accordance with a preferred embodiment of the present invention;

Figure 11c is a front cross-sectional view of a spreader discharge at various angles of tilt;

Figure 11d is a front cross-sectional view of a spreader discharge in concave and convex positions;

Figure 12 is a flow diagram of the process control loops used to control the flow of potatoes throughout the system shown in **Figure 5** in accordance with a preferred embodiment of the present invention;

Figure 13 is a perspective view of an oversized-product separator and a segmented cutter in accordance with one embodiment of the present invention; and

Figure 14 is an enlarged perspective view of the segmented cutter shown in **Figure 13**.

DETAILED DESCRIPTION

Food Processing System

While the invention is described below with respect to a preferred embodiment in which potatoes are reduced using a plurality of transverse slicers, other embodiments are possible. The concepts disclosed herein apply equally to systems for slicing other types of produce and food items including vegetables, tubers, nuts, and fruit. Furthermore, the invention is not limited to the use of transverse slicers, and other types of slicers can be used. It should also be noted that in the illustrated embodiments, the various objects and layers are drawn at a scale suitable for illustration rather than at the scale of the actual material.

Figure 5 is a flow chart of a food processing / slicing system having one or more slicers **580** in accordance with one embodiment of the present invention. The path of the product to be sliced is represented by solid lines, and the presence of water is represented with dotted lines. In a preferred embodiment, whole peeled potatoes **502**, which can be round and/or oblong, first enter an oversized-product separator **510**. This separator **510** ensures that oversized potatoes and potato pieces **514** will not jam the feed tubes of the potato slicers **580** located further downstream. In a preferred embodiment, the oversized-product separator **510** comprises a plurality of parallel augers or screws that are spaced such that any potatoes or potato pieces having diameters smaller than the diameter of the downstream slicer feed tubes can pass between the augers. Peeled potatoes **502** are poured over the plurality of parallel augers, and the acceptably sized (normal sized) potatoes and potato pieces **512** pass through the separator **510** and are moved downstream for further processing. Oversized potatoes and potato pieces **514**, which are

those having diameters larger than the diameter of downstream slicer feed tubes, will instead remain supported upon the augers. In operation, the augers rotate along their long axes so that the oversized potatoes are carried to a separate container or conveyor. The oversized potatoes and pieces **514** are then sent to a segmented cutter **515** that reduces their diameters. The reduced-diameter segments **518** are then returned to the potato feed stream **502** entering the separator **510**. If the reduced-diameter segments **518** still have minor-dimension diameters (diameters measured within a plane perpendicular to the long axis of the potato or segment) that are too large for the downstream slicers, they will again be separated from the feed stream **502** and processed through the segmented cutter **515**. This cycle will continue until the oversized pieces are reduced to an acceptable size. It is also possible, however, to feed the reduced-diameter segments **518** into the stream of acceptably sized potatoes and potato pieces **512** exiting the separator **510**.

A segmented cutter **515** reduces the diameter of oversized potatoes **514** by forcing such potatoes through a set of blades. Oblong potatoes are first oriented so that their longest axis is approximately parallel to the blades. The potatoes are then cut approximately lengthwise in order to decrease the diameter about the long axis (the diameter in the minor dimension). A variety of devices can be used to reduce the diameter of the potatoes and potato pieces. In a preferred embodiment, the segmented cutter comprises three curved blades radiating from a shared axis and secured at their radial ends to the inner surface of a cylinder. The shared axis is preferably parallel to the centerline of the cylinder. If desired, the blades can be moved during operation so that their shared axis aligns with the long axis of the potato to be segmented. Because consumers tend to dislike potato chips having straight edges, the segmented cutter's

blades should curve as they radiate outwards from the center of the cutter to the surrounding cylinder. Other blade orientations are possible, and more or less than three blades can be used if desired. The segmented cutter should cut each oversized potato into a minimum of two lengthwise segments in order to ensure that the majority of resulting segments have diameters less than that of the cut oversized potato. Because most potatoes are not perfectly symmetrical, a single-blade segmented cutter having a one blade will usually be sufficient to reduce each over-sized potato into two halves/segments, with each segment having a diameter smaller than the whole potato. Furthermore, even if the resulting segments still have diameters that are too large, the segments can be recycled through the separator and segmented cutter until the lengthwise segments ultimately have acceptable diameters.

In the potato slicing system shown in **Figure 5**, the acceptably sized potatoes **512** exiting the oversized-product separator **510** then pass through a mass-flow/spreading conveyor **520** before being divided into two or more lanes by a diverter **530**. The mass-flow/spreading conveyor **520** controls the flow rate of potatoes entering the diverter **530**. As will be explained in more detail, the flow rate of potatoes **512** passing through the mass-flow/spreading conveyor is preferably adjusted according to downstream supply, demand, and capacity conditions.

The mass-flow/spreading conveyor **520** can comprise a metering belt, a screw feeder, mass/weigh conveyor, vibratory conveyor or various combinations thereof. In a preferred embodiment, the mass-flow/spreading conveyor comprises a vibratory conveyor, such as an accumulation/distribution vibratory conveyor manufactured by FMC Technologies, followed by a vibratory mass/weigh conveyor such as that disclosed

in U.S. Patent No. 5,780,780, granted to Ahmed. The vibratory conveyor helps evenly spread the flow of potatoes **512** onto the weigh conveyor. The weigh conveyor, which can comprise of load cells for measuring weight, is designed to carry a specific range of weight. The speed of the vibratory conveyor can be adjusted to ensure that the desired mass flow rate is conveyed through the weigh conveyor. If desired, a metering belt or conveyor can also be used in addition to, or instead of, the vibratory and weigh conveyors in order to help regulate the flow of potatoes. For example, an incline metering belt can be used to transfer a metered flow of potatoes onto the vibratory conveyor. Such an incline metering belt can also be used before the oversized-product separator **510** to transfer a controlled flow of potatoes from a hopper (or other storage area) to the separator **510**. In another embodiment, the mass-flow/spreading conveyor can comprise a hopper-fed load-cell conveyor. The hopper spans the width of the conveyor and feeds a constant depth of potatoes onto the conveyor. The velocity of the conveyor can then be adjusted to control the flow rate of the potatoes.

If the regulated flow of potatoes **522** will supply more than one downstream slicer **580**, the potatoes **522** will then enter a diverter stage **530** to be divided into two or more potato streams **532**. A column of water within the diverter stage, which can be of any depth within the structure, provides a supportive medium through which the potatoes can gently descend. At least one diverter, or movable divider, divides the flow of potatoes **522** into two or more streams of potatoes **532**. Thereafter, the streams of potatoes **532** are kept apart by stationary dividers, separate channels, pipes, or conveyors, and each stream of potatoes **532** is lead into an eductor stage **540** where the potatoes **532** are propelled further downstream. In a preferred embodiment, the diverter stage comprises a

descending structure that encloses a descending passage and has one or more fixed dividers. These dividers segregate the lower portion of the descending passage into two or more channels (or lanes). The diverter stage, however, need not be perfectly vertical and can be also be at an angle. Moveable or flexible dividers are attached to the top ends of some or all of the fixed dividers. More preferably, a movable, rigid divider is hinged at its bottom end to the top of each fixed divider.

Once the potatoes **522** have been divided into two or more streams, each stream of potatoes **532** is propelled by an eductor **540** towards that stream's respective slicer **580**. Note that while **Figure 5** depicts four streams of potatoes, each stream passing through its own eductor **540**, dewatering stage **550**, slicer infeed conveyor **570** and slicer **580**, any number of streams are possible. If desired, the fluid flowing through all of the eductors **540** can be supplied by a common water supply and propelled by a common pump. The ability to divide a single supply of water into several independently controllable streams adds flexibility to the system and reduces capital and operating costs. Whereas a multi-slicer system might otherwise require separate conveyor systems or individual pump-and-flume systems to supply each slicer, the diverter-eductor system of the present invention allows one to use a single source of water and a single pump to transfer potatoes to each slicer. Each eductor **540** comprises a fluid jet pump that propels a fluid flow **564** (or eductor flume) through a section of a pipe or channel to which a product in-feed line **532** is also connected. This section of pipe, to which the product in-feed line **532** is connected, is preferably a narrowing section, and each eductor **540** preferrably accelerates the fluid flow **564** through the narrowing section to reduce the static pressure of the fluid in the product in-feed area. As the fluid flow **564** accelerates

through the narrowing section, the fluid flow **564** creates a low pressure due to Bernoulli's principle. This low pressure (or suction) draws product **532** into the fluid flow **564**. However, the product in-feed area need not be in a narrowing section of pipe in applications where the food items naturally fall down into the eductor flumes under the force of gravity. The fluid flow **542** then carries the product **532** onward for further processing. Unlike prior art centrifugal-type food pumps, eductors do not have moving blades or turbines that can damage product being conveyed. In fact, eductors require no moving parts and are thus gentler on the product than the prior art centrifugal-type food pumps. While water is used as the fluid medium in a preferred embodiment, other fluids such as cooking oil can also be used to transport the food items.

Each stream of potatoes **542** is propelled along a jet stream of water ("eductor flume") from the eductor stage **540** to a dewatering stage **550**, which is typically located fairly close to a corresponding slicer **580**. The dewatering stage **550** is used to separate the water stream **554** from the potato stream **552**. The separated water stream **554** then passes through a swirl tank **560** before being recycled **564** to the diverter and eductor stages **530** and **540**. Recycled water **562** can be removed from, and fresh water **566** can be supplied to, the swirl tank **560** in order to control the concentration of starch, fines, and other particles, as well as control the amount of water flowing through the system. If desired, filters, cyclones, and other devices known in the art can be used to remove particulates from the recycled water. Once the potatoes **552** have been dewatered, the slicer infeed conveyor **570** transfers the flow of potatoes **572** into each slicer **580**. Jets of water **597** may be introduced into the feed tubes for several reasons. One benefit of providing a wet environment during slicing is that it reduces starch buildup in the slicers

580. A second benefit of water jets **597** is that they can be used to orient the potatoes **572** for proper slicing. They can also be used to push the potatoes **572** to the leading side of the feed tubes, which is where the cutting blades will eventually lead the potatoes **572**. A third benefit of water jets **597** is that they can be used to press the potatoes **572** against the blades with a constant pressure. Applying a constant pressure on the potatoes **572** helps minimize unwanted variation in slice thickness. The slices **582** exiting the slicers **580** are transported along a flume of water **597** into a slice spreader **590**, which controllably distributes the slices **592** onto a conveyor in a slice dewatering stage **592** for further processing. As will be explained in more detail, feedback from downstream processes units, such as a fryer, can be used to adjust the way in which the slice spreader **590** distributes slices **591** onto the conveyor. A starch removal unit **595** can also be used to remove any starch and other particles **596** entrained in the water drained from the potatoes **594** in the slice dewatering stage **595**. Fresh water **598** may be added to the recycle stream **597** flowing from the starch removal unit **595** to the slicers **580** and slice flumes to maintain the desired flow rate and turnover rate.

Oversized-Product Separator

Figure 6 depicts an example of multiple, parallel augers **610** separating an oversized potato **614** from the rest of a potato feed **602**, in accordance with a preferred embodiment. Oversized potatoes **614** are carried upon the parallel augers **610** and deposited onto a conveyor that leads the oversized potatoes **614** to a segmented cutter. The acceptably sized potatoes fall between the augers **610** and are collected and conveyed downstream for further processing.

Figure 13 is a perspective view of an oversized-product separator and a segmented cutter in accordance with one embodiment of the present invention. In the embodiment shown in **Figure 13,** a first incline conveyor **1310** raises potatoes up to a vibratory conveyor **1312**. The vibratory conveyor **1312** evenly spreads the potatoes and distributes them onto the parallel augers of an oversized-product separator **1314**. Normal sized potatoes fall through the augers **1314** and into a collecting chute **1328**, which then directs the potatoes onto an incline metering conveyor **1330** for further processing.

As the parallel augers rotate, they move any potatoes too large to fall between the augers (oversized potatoes) to the end of the separator and onto an oversized-product collecting conveyor **1316**. The oversized potatoes are then conveyed along another conveyor **1318** to an accelerating chute **1320**. The oversized potatoes drop into and accelerate down the accelerating chute **1320** under the force of gravity and pass through a segmented cutter **1324** located at the bottom of the chute **1320**. If desired, water, oil, or some other liquid can be introduced into the chute **1320** to help the potatoes slide down the chute without tipping end over end. After passing through the segmented cutter **1324**, the resulting potato segments are transferred along a return conveyor **1326** back onto the first incline conveyor **1310**.

Figure 14 is an enlarged perspective view of the segmented cutter shown in **Figure 13**. The accelerating chute **1324** leading into the segmented cutter **1324** is preferably round and tilted downwards but not completely vertical. As the potatoes slide down the chute **1320**, they naturally align themselves lengthwise down the chute. For ease of removal, the segmented cutter can be mounted on a plate **1322** having handles. In a preferred embodiment, the plate **1322** is easily secured and removed from between the

chute **1320** and a support block **1323**. The potato segments exiting the segmented cutter **1324** then slide down the terminal portion of the chute **1325** and onto the return conveyor **1326**. Although the terminal portion of the chute **1325** is an open channel having a rectangular cross-section in the embodiment shown in **Figures 13** and **14**, the terminal portion of the chute **1325** can be of any cross-sectional shape. For example, the terminal portion **1325** can instead comprise a circular tube or a v-shaped channel.

Note, however, that while product is accelerated under the force of gravity through a segmented cutter in a preferred embodiment, other methods of reducing product using a segmented cutter are possible. For example, product may instead be held stationary while a segmented cutter moves down the lengthwise axis to form smaller-diameter segments.

Segmented Cutter

Figure 7a is a front elevational view of an oblong potato **710** being cut by a tri-blade segmented cutter **720** having curved blades **730** that radiate from a shared center, in accordance with a preferred embodiment. **Figure 7b** is a side elevational view of an oblong potato **710** being cut by the tri-blade segmented cutter **720** shown in **Figure 7a**. Straight blades, however, can still be used to reduce the potato diameters. **Figures 7c** and **7d**, for example, show a front elevational view and a perspective view of an oblong potato **740** being cut by a tri-blade segmented cutter **742** having straight blades **744** that radiate from a shared center.

A segmented cutter having any number of blades, however, can be used, as long as the cutter divides food pieces into smaller lengthwise segments. More than three blades, or as few as one blade, can be used. **Figures 7g** and **7h** are, respectively, a front

elevational view and a perspective view of an oblong potato being cut by a segmented cutter having a single straight blade in accordance with one embodiment. As explained above, most potatoes tend to be flatter in one dimension. Thus, by orienting a potato so that its flatter dimension is perpendicular to the blade **764**, the single-blade segmented cutter **762** will divide the potato **760** into two lengthwise segments, each having a minor-dimension diameter smaller than that of the original potato **760**.

Other types of segmented cutters can be used to reduce the minor-dimension diameters of potatoes and potato pieces. For example, U.S. Patent No. 5,390,590, granted to Mendenhall, discloses a device for cutting a potato into a plurality of pieces using a fixed array of stationary blades. Prior art potato halvers, however, do not reduce the minor-dimension diameters of potatoes and potato pieces as efficiently as would a tri-segmented cutter in a preferred embodiment. **Figures 7e** and **7f** show a front elevational view and a perspective view of an oblong potato **750** being cut by a prior art potato halver. As seen in **Figures 7e** and **7f**, a prior art potato halver's blade **754** cuts an elongated/oblong potato, secured by supports **752**, lengthwise into two pieces, both pieces having diameters substantially similar or equal to the diameter of the whole potato before cutting. Such prior art halvers provide inefficient means for reducing the minor-dimension diameters of potatoes or potato pieces. Thus they cannot be effectively used where such potatoes or pieces will be fed lengthwise into transverse slicers.

Diverter and Eductor Stages

Figure 8a is a side cross-sectional view of a diverter stage **802** and an eductor stage **850** in accordance with a preferred embodiment of the invention. **Figure 8b** is a

front cross-sectional view of the diverter stage **802** and the eductor stage **850** shown in **Figure 8a**, and **Figure 8c** is a front cross-sectional view of one diverter of the diverter stage **802** shown in **Figure 8a**. **Figures 8b** and **8c** both depict the diverters in various positions in order to show the extent of their movement. In **Figure 8a**, the diverter stage **802** comprises a descending housing **810** that encloses several movable diverters. While the descending housing **810** of the diverter stage **802** is substantially vertical in a preferred embodiment, the diverter stage **802** need not be perfectly vertical and can instead be at an angle if desired. A feed conveyor **820** or other feed means introduces potatoes to the top of the descending housing **810**. In a preferred embodiment, the feed conveyor **820** comprises the vibratory and/or weigh conveyor of the mass-flow/spreading conveyor. Note, however, that the diverter and eductor stages **802, 850** can be used to used in other applications to divide and propel a flow of food items, and the diverter and eductor stages **802, 850** need not be limited to transporting potatoes from a mass-flow/spreading conveyor to slicers. The diverter and eductor stages **802, 850**, for example, can be used simply to divide a flow of food items and hydraulically transport the items from one place to another. A movable plate **814** hinged to the upstream side of the descending housing **810** can be positioned to bridge the gap between the feed conveyor **820**, as well as control the flow of potatoes into the diverter. When the plate **814** is positioned to completely bridge the gap, the potatoes flow unimpeded into the diverter stage **802**. When the plate **814** is angled upwards and away from the feed conveyor **820**, the potatoes are prevented from entering the diverter stage **802** and are directed into a bypass hopper **817**. While the bypass hopper **817** is an open container in the embodiment shown in **Figure 8a**, the bypass hopper **817** can comprise any structure

for receiving potatoes such as a chute, trough, or a return conveyor. Between the bypass hopper **817** and the descending housing **810** is a water receptacle **816** having a drain. The water receptacle **816** collects any water that falls from the potatoes and/or splashes out of the diverter stage **802** as the potatoes drop into the water in the descending housing **810** from the feed conveyor **820**. A grate or other water-pervious structure can be placed at an angle over the top of the water receptacle **816** to ensure that any bypassed potatoes do not enter the water receptacle **816**. If the plate **814** is angled horizontally or downward into the bypass hopper **816**, some of the potatoes will flow into the diverter stage **802,** and some will flow into the bypass hopper **816**. Due to the hydrostatic pressure at the bottom of the descending housing **810**, water collects in the descending housing **810** to form a column of water. **Figure 8a** shows a waterline **818** at the top of the column of water. As potatoes enter the descending housing **810** of the diverter stage **802,** a flow of water can also be introduced into the top of the descending housing **810**. This downward flow of water helps force down any floating potatoes. If desired, water can first be introduced into a reservoir **812** attached to the outside of the descending housing **810**. The water fills the reservoir **812** and then flows over a weir between the reservoir **812** and the descending housing **810** into the diverter stage **802**. Note, however, that the waterline/level **818** is independent of the downward flow rate of water entering the descending housing **810**. This is because the waterline/level **818** depends on the hydrostatic pressure at the bottom of the descending housing **810** and not the downward flow rate of water.

Depending on where the waterline **818** is, the movable diverters may or may not be submerged in water. The water in the diverter stage **802** softens the potatoes' descent

downward, as the potatoes encounter more drag when traveling through water than through air. Furthermore, water itself supports much of the weight of the potatoes, as the specific gravity of potatoes usually falls between 1.08 and 1.1. The water thus provides the potatoes a more gentle passage through the diverter stage. Thus, the higher the waterline **818**, the shorter the distance the potatoes must fall and accelerate through the air before entering the water and/or encountering the diverters, and the more gentle the potatoes' descent will be. In a preferred embodiment, the water completely submerges the diverters, and the waterline **818** is as high as possible, near the top of the descending housing **810**. For a given installation pressure (or head pressure), the level in the diverter stage can be controlled by adjusting the eductor settings, as will be explained in more detail below.

As seen in **Figure 8b**, the descending housing **810** of the diverter stage **802** encloses three fixed dividers **822** and three movable diverters **824** hinged at their bottoms to the top of the three fixed dividers **822**. These diverters **824** and dividers **822** distribute a downward flow of potatoes among four lanes or channels **831, 832, 833, 834**. If desired, the diverters **824** and/or dividers **822** can be perforated rather than solid in order to allow water to pass through, thereby allowing the water pressure and water levels to equalize throughout the diverter stage **802**. The top ends of the movable diverters **824** are attached to three linear positioning members **826** that move within a horizontal positioning carriage **828**. In a preferred embodiment, the positioning carriage **828** comprises several rod-less cylinder magnetic positioners. Each diverter **824** is attached to its own magnetic positioner. Alternatively, the positioning carriage **828** can simply comprise several pulleys and belts to which the positioning members **826** are attached. In

such case, the pulleys are rotated in order to move the belts and the attached positioning members **826**. In other embodiments, the movable diverters **824** can be positioned with other devices including mechanical/manual, hydraulic and pneumatic devices, and electric servos.

Figure 8c shows an enlarged view of one moveable diverter in accordance with a preferred embodiment of the invention. As shown in **Figure 8c**, each positioning member **826** should be able to accommodate some variance in the vertical position of the point of contact with the corresponding movable diverter. This variance is due to the change in vertical height of each positioning member **826** as it hinges about the top of the corresponding fixed divider. Each positioning member **826** can, for example, comprise a stiff plate or rail having a vertical slot in which a peg, pin or bolt attached to the top of each moveable diverter can move up and down while being held firmly in a desired horizontal position.

Figure 8d is a perspective view of several positioning carriages **828**, one for each diverter, in accordance with a preferred embodiment. Each diverter **824** is attached at its top to a positioning member **826**, and each positioning member **826** moves horizontally along its own rod-less cylinder magnetic positioner (not shown) within its positioning carriage **828**. In the embodiment shown in **Figure 8d**, positioning sensors along the top of each positioning carriage **828** track the positions of the positioning members **826** and provide feedback to the rod-less cylinder magnetic positiners. **Figure 8d** shows several potatoes **830** being transferred from a feed conveyor into the top of the diverter stage.

Returning to **Figure 8b**, each movable diverter **824** can be moved to alter the distribution of potatoes introduced from above. The position of the diverters **824** affects

the flow of top water and potatoes (or other product) into each lane by altering the horizontal cross-sectional area of the downward flow that is diverted into each lane. For example, in order to increase the flow of potatoes to the first lane (left-most lane) **831** and decrease the flow to the other three lanes **832, 833, 834**, the left diverter can be moved to the right in order to increase the cross-sectional area of the downward flow of potatoes diverted into the first lane **831**. The center and right diverter must also be moved to the right, although to different degrees, in order to evenly divide the remaining downward flow of potatoes among the second, third, and fourth lanes **832, 833, 834**. As a second example, the center diverter can be positioned vertically and the left and right diverters angled towards the center diverter in order to increase the flow of potatoes to the first and fourth lanes **831, 834** and decrease the flow of potatoes to the second and third lanes **832, 833**. Likewise, the diverters can also be moved to shut off the potato flow to one or more lanes. As will be explained in more detail below, the positioning members **826** can be programmed to respond to an imbalanced distribution of work among the slicers, to balance the speed of the slicers, or to divert the flow of potatoes away from a plugged slicer.

After being diverted into four lanes, the potatoes enter an eductor stage **850** where they are drawn along jet streams of water towards the slicers. **Figure 8a** shows a side cross-sectional view of an eductor **850** in accordance with a preferred embodiment of the present invention. **Figure 8b** shows a front cross-sectional view of a manifold of several eductors in accordance with a preferred embodiment of the present invention. The use of a separate eductor for each lane adds flexibility to the system, as each eductor can be adjusted according to the properties and operating conditions of each lane. For example,

if the eductor infeed tubes are all of different lengths, or if each lane of product must be propelled to a different distance or height, each eductor can be operated at a different flow rate and/or pumping pressure in order to accommodate the unique conditions of each lane. The eductor **850** shown in **Figure 8a** comprises a water jet (eductor) inlet pipe **852**, a product drawing section T-section **854**, and a discharge pipe **856**. Water can be supplied to the inlet pipe **852** with any pump suitable for moving liquids, such as a centrifugal or positive displacement pump. The bottom of the diverters feed perpendicularly into an eductor flow between the eductor inlet and outlet pipes **852**, **856**, thus forming several T-sections **854**. In a preferred embodiment, the product-drawing T-sections **854** have square or rectangular cross-sections, while the inlet and outlet pipes **852**, **856** have circular cross-sections. Thus, the round inlet and outlet pipes **852**, **856** feed into and out of a rectangular manifold of product-drawing T-sections **854**. Other cross-sectional shapes, however, can be used for the inlet and outlet pipes **852**, **856** and the T-sections **854**. The T-sections **854**, for example, can be round if desired. The water pressure of the water passing through the inlet pipe **852** supports a head of water in the diverter stage **802** and determines the height of the water level **818**. If desired, a restrictive valve **858** can be placed just upstream of the T-section **854** to help control the water level **818** in the diverter stage **802**. In a preferred embodiment, the restrictive valve **858** has a flat plate hinged slightly upstream from an moveable valve stem. The angle of the flat plate, and thus the level of restriction, is varied by the vertical position of the valve stem. Other embodiments of the restrictive valve **858**, however, are possible. When the valve **854** restricts the cross-sectional area through which the water can pass, the water is forced to accelerate through restricted area to maintain a constant volumetric

flow rate. The total energy of the motive water shifts from static pressure to kinetic energy, thus lowering the static pressure of the water in the area surrounding the restrictive valve **858**. The area surrounding the restrictive valve **858**, which includes the product-drawing T-section **854**, then becomes a lower-pressure area with respect to the eductor inlet and outlet areas **852, 856**. The water level **818** in the diverter stage, which is determined by the static pressure of the water in the product-drawing T-section **854**, therefore decreases as the level of valve restriction increases.

As potatoes have a specific gravity ranging from about 1.08 to 1.10, potatoes generally descend down the column of water and into the product-drawing T-section **854** under the force of gravity. Some potatoes, however, may contain air pockets that cause them to float, preventing them from descending down the diverter stage **802** under the force of gravity alone. Thus, in a preferred embodiment, water is introduced into the top of the diverter stage **802** in order to create a downward current of water (or "top water") sufficient to force the buoyant potatoes down the diverter stage **802** and into the product-drawing T-section **854**. For example, a top water flow having a downward vertical velocity of about 0.2 to about 2.0 feet per second is usually sufficient to force buoyant potatoes down the diverter stage **802**. If other food items are used, a faster downward flow rate of water can be used to force less dense food items down the diverter stage and into the eductor stage **850**. The less dense the food item, the faster the flow rate must be in order to force the food items down. In fact, even food items less dense than water, such as apples which have a specific gravity ranging from about 0.75 to about 0.82, can be forced down the diverter stage as long as the flow rate of the water is fast enough.

As the jet stream of water flows through the valve **858** and passes the product drawing section **854** at high velocity, the jet stream of water draws the descending potatoes (and water if cycled into the diverter stage) from the above diverter stage **802**. Once drawn into the jet stream of water, the potatoes are then propelled along with the water through the discharge pipe **856** towards the slicers. The potato-laden eductor flume expands from its previously restricted cross-sectional area to a larger cross-sectional area in the discharge pipe **856**. The total energy (static and kinetic energy) of the streams of water passing through the eductor stage **850** and diverter stage **802** affects the distance and elevation to which the potatoes can be transported. For example, the more pumping energy expended, the further the potatoes can be moved. With no moving parts, eductors are more gentle on the potatoes than prior art centrifugal-type pumps. Furthermore, the lack of moving parts makes eductors easy to maintain and operate.

The potatoes and water can be discharged to a dewatering stage at a point that is below or above the water level **818** in the diverter stage **802**. The final elevation and distance, however, will determine the degree of gentleness with which the potatoes can be moved. For example, if the potatoes only need to be transported a short distance and to a point that is below the water level **818** in the diverter stage **802**, a relatively low pumping pressure will be sufficient to move the potatoes to the dewatering stage. The lower the pressure employed, the more gently the potatoes can be moved. If the potatoes must be transported a long distance or to an elevation higher than the water level **818** in the diverter stage **802**, the pumping pressure through the eductors **850** must be increased. This reduces the level of gentleness with which the potatoes may be moved. To maintain the desired water level **818** in the diverter stage **802**, the valve restriction must be

increased to accommodate a greater static pressure differential between the eductor inlet **852** and the T-section **854**. Increasing the restriction causes the water's velocity through the T-section **854** to increase, which further reduces the gentleness with which the potatoes can be transported. Even so, eductors **850** provide a more gentle method of conveying potatoes than the prior art centrifugal-type impeller pumps.

Figure 9 is a side cross-sectional view of another embodiment of an eductor. Note, however, that the eductor shown in **Figure 9** is not drawn to scale. **Figure 9** simply illustrates conceptually the parts of the eductor and their relative positions. Like the eductor shown in **Figure 8a**, the eductor shown in **Figure 9** comprises a water jet inlet pipe **952**, a product drawing section **954**, and a discharge pipe **956**. The eductor shown in **Figure 9**, however, has a jet inlet pipe **952** that extends into, and is concentrically nested within, a portion of the product drawing section **954**. The product drawing section **954** narrows to form a venturi neck **962** before expanding into the discharge pipe **956**. Although the product drawing section **954** narrows at the venturi neck **962**, the inner diameter must still be large enough to accommodate the food items being propelled through the eductor. The jet inlet pipe **952** also has a narrowing terminal portion **960** near the venturi neck **962**. In this embodiment, water flowing through the inlet pipe **952** increases in velocity as it passes through the narrowing terminal portion **960**. As the water flows past the product drawing section **954**, it draws potatoes from the descending housing of the diverter stage. The water and potatoes then continue through the venturi neck **962** and then spread out in the discharge pipe **956**. The eductor flume (water jet) then propels the potatoes further along the process. Note, however, that in other embodiments of the eductors, the product drawing sections need not narrow to form

venturi necks. For example, products denser than water can simply be introduced under the force of gravity into motive fluid flowing in a simple pipe or channel rather through a narrowing section of pipe.

In yet another embodiment, ring-type eductors can be used to draw the potatoes and propel the potatoes downstream. A ring-type eductor has two concentrically nested tubes – an outer tube and an inner tube – in which the inner tube supplies the product to be drawn and propelled, and the space between the inner tube and the outer tube is used to supply the propelling fluid. The inner tube terminates with an open end within the outer tube where the product is to be drawn. As the propelling fluid flows through the space between the inner and outer tube and passes the terminal, open end of the inner tube, the fluid draws product out from the inner tube and into the fluid flow. In the alternative, a plurality of smaller jets can be used to draw product out of a product-supplying tube. Note, however, that while several embodiments of eductors have been described herein, other types of eductors, including those well-known in the art, can also be used in accordance with the present invention.

Hydraulically conveying food items, such as potatoes and potato slices, along an enclosed flume of fluid such as water provides at least three advantages over mechanical transporting methods: 1) it adds flexibility to the routing and layout of the transporting path, 2) it is more sanitary, and 3) it provides a faster method of transportation than traditional mechanical means. First, whereas an incline conveyor might otherwise be required to move the food items up and over certain obstacles in a slicing facility, the present invention's method for transporting food items allows simple siphoning action to be used to accomplish the same task. When the food items are transported along an

enclosed flume of water, the flume of food items and water can be siphoned above certain obstacles in the plant before leading the flume back down to the elevation of the flume discharge. This enables food items to be temporarily raised in elevation without additional energy input, and it also adds flexibility to the ways in which the food items can be routed throughout the facility. Second, the enclosed nature of flume transportation allows the food items to be transported directly through unsanitized areas without danger of contamination. Furthermore, the fluidizing and subsequent dewatering/draining of the food items acts as a washing and filtration step that helps remove undesirable foreign materials. Third, whereas prior art conveyors typically operate at a rate of about 30 to about 50 feet/minute, a relatively slow food item flume runs at about 180 feet/minute. Transporting food items through a flume of fluid is thus much faster than typical prior art mechanical methods.

Furthermore, the diverter-eductor system of the present invention allows one to use a single source of water and a single pump to transfer potatoes to each slicer of a multi-slicer system. Without such a diverter-eductor system, such a multi-slicer system might otherwise require separate conveyor systems or individual pump-and-flume systems to supply each slicer. Thus, the diverter-eductor system's ability to divide a single supply of water into several independently controllable streams adds flexibility to the system and reduces capital and operating costs.

Dewatering Stages

Figures 10a and 10b depict dewatering stages **1010** in accordance with a preferred embodiment of the present invention. U.S. Patent No. 6,540,911, granted to

Bajema, for example, also discloses a dewatering system in accordance with a preferred embodiment of the present invention. As shown in **Figures 10a** and **10b**, each eductor flume **1012** of potatoes and water is discharged over a declining slotted ramp **1014** having holes or slots through which water but not potatoes can pass. As the potatoes **1020** tumble and slide down the ramp **1014**, the water drains from the potatoes **1020** and through the slotted ramp **1014** to a water receptacle. The potatoes **1020** are then discharged from the ramp **1014** onto a slicer infeed conveyor **1050**. Although the ramp **1014** shown in **Figures 10a** and **10b** comprises evenly spaced metal strips, other embodiments of passive dewatering systems are possible. For example, the ramp **1014** can comprise a plurality of strips of other materials such as plastic, rubber, alloy, wood, and ceramic. The ramp can also comprise a grid structure or holed surface if desired. In an alternate embodiment, the dewatering stage **1010** can comprise an active dewatering system such as a rotating screen, rope conveyor, or vibratory conveyor. Such a screen or conveyor can be made of wire mesh, a plurality of ropes or chains, or a flexible grid.

Slicer Infeed Conveyors

Returning to **Figures 10a** and **10b**, the figures also show two slicer infeed conveyors **1050** in accordance with a preferred embodiment of the present invention. There is one slicer infeed conveyor **1050** for each stream of potatoes **1020** discharged from the eductor stage. Each slicer infeed conveyor **1050** shown in **Figure 10** comprises a vibratory conveyor, preferably on load cells, that evenly spreads a flow of potatoes **1020** into multiple lanes. The slicer infeed conveyors accomplish four main functions: 1) evenly spread a flow of potatoes across a given area feeding into several lanes; 2)

distribute the potatoes uniformly among several lanes; 3) align the potatoes substantially lengthwise and single-file down the several lanes; and 4) feed each lane of oriented potatoes into a corresponding feed tube of a slicer. By using load cells to maintain a constant mass on the slicer infeed vibratory conveyor **1050**, one can ensure that the conveyor discharges the same mass flow rate that it receives and does not accumulate or dissipate mass, which can occur with typical vibratory conveyors. Typical vibratory conveyors without load cells transport different sized potatoes at different rates, thus the momentary mass flow rate exiting such conveyors does not always equal the momentary entering mass flow rate at a given point in time.

The first portion **1052** of each slicer infeed conveyor **1050** comprises a relatively flat vibratory surface for evenly spreading the dewatered potatoes **1020**. This first portion **1052** may or may not be connected to a second portion **1054**. **Figure 10a** shows a double-conveyor embodiment in which the first portion **1052** is adjacent but not connected to the second portion **1054**. The separation of the first portion **1052** from the second portion **1054** allows the portions **1052, 1054** to be separately controlled if desired. **Figure 10b** shows a more preferable single-conveyor embodiment in which the first portion **1052** and second portion **1054** are attached to each other as part of the same conveyor. The second portion **1054** is a dividing segment that includes several evenly spaced dividers **1056**. These dividers **1056** run the length of the latter portion of the vibratory conveyor and divide the flow of potatoes into five lanes in a preferred embodiment, with each lane feeding into a separate slicer feed tube. While the embodiments shown in **Figures 10a and 10b** include four dividers **1056** for each slicer infeed conveyor **1050**, more or less dividers **1056** can be used depending on the number

of feed tubes the downstream slicer has. Sensors **1060** can be positioned in various locations over one or more lanes of the slicer infeed conveyor **1050**. As will be explained in more detail below, these sensors **1060** can be used to measure the velocities and/or the duty cycles of the potatoes. Although the sensors **1060** are preferably located near the end of the infeed conveyors **1050**, the sensors **1060** can also be located elsewhere. At the end of each lane is a ramp or a downward-sloping chute for leading and reorienting the potatoes into a corresponding feed tube. Each potato enters the corresponding ramp substantially horizontal but then transfers from the ramp into the feed tube in a substantially vertical position (long axis in a substantially vertical position). Note, however, that larger elongated potatoes may tend to align themselves more vertically than smaller or shorter potatoes.

Other embodiments of the slicer infeed conveyor are possible. Any apparatus for transferring potatoes into a slicer can be used. For example, a slicer infeed conveyor can simply comprise a vibratory conveyor that feeds directly into one or more feed tubes of a slicer. A slicer infeed conveyor can also comprise a dewatered potato bin and an incline metering conveyor for transferring a controlled flow rate of potatoes into the corresponding slicer. In yet another embodiment, the slicer infeed conveyor comprises a belt conveyor. Belt conveyors and metering conveyors, however, can be more difficult to maintain and sanitize than vibratory conveyors. Belt conveyors and metering conveyors may also make it more difficult to uniformly distribute potatoes to each feed tube.

Slicers

Returning to the flow chart of the potato slicing system shown in **Figure 5**, each slicer infeed conveyor **570** discharges several lanes of potatoes **572** into a corresponding slicer **580**. In a preferred embodiment, transverse slicers **580** are used to process the potatoes **572**. Other types of slicers, however, can be used. **Figure 2** is a perspective view of one embodiment of a transverse slicer **200** suitable for use with the present invention's food processing system. **Figure 3** is a side cross-sectional view of the transverse slicer shown in **Figure 2**. Unlike a prior art centrifugal slicer, a transverse slicer **200** such as that depicted in **Figures 2** and **3** is capable of forming round slices from either round potatoes or oblong potatoes. Furthermore, a transverse slicer does not require a minimum operating speed and can therefore operate at reduced slicing speeds. The transverse slicer **200** shown in **Figures 2** and **3** comprises a rotary slicing wheel or disk **210** having at least one blade or slit **212** for slicing. The leading edge of the blade **212** (or trailing edge of the slit) is slightly higher in elevation than the adjacent slicing wheel or disk **210** surface, leaving a gap through which slices pass. The size of the gap determines the slice thickness. The slicing wheel **210** rotates about an axle **214**. A feed tube **220** leads potatoes **230** in single file to the slicing wheel **210** to be sliced into slices **232**. One or more inlets **222** introduce a fluid, such as water or oil, into the feed tube **220** to help fluidize the slices and lubricate the cutting process. As explained above, jets of fluid may be introduced into the feed tubes for several reasons: 1) they help minimize scrap generation, 2) they can be used to align the potatoes for proper slicing, and 3) they can be used to press the potatoes **572** against the blades with a constant pressure, thereby minimizing unwanted variation in slice thickness. All three benefits can be served if the

fluid jets are angled downward and towards the shear edge (cutting edge) of the feed tubes. The shear edge of the feed tubes is the portion of the tube against which the potatoes are pressed as the slicing wheel rotates. Miscuts can occur if the potato being sliced is not already against the shear edge when the potato first comes in contact with a blade. Using fluid jets to stabilize the potatoes thus helps reduce scrap generation and increase yield. Note, however, that other methods for aligning and applying pressure to the potatoes are possible, including mechanical methods. A slicer skirt **216** shrouds the slicing wheel **210** and the area beneath the slicing wheel **210** where freshly cut slices **232** fall and/or collect. As potato slices **232** are cut from potatoes **230**, the slices **232** can be collected for transportation to another processing unit. In a preferred embodiment as shown in **Figure 5**, the slices **582** are collected by a flume of water under each slicer **580** and transported to a slice spreader **590**. Several of the flumes may combine before entering the slice spreader **590**. Transporting the slices **582** in flumes of water offers several advantages over prior art mechanical methods of conveying. One advantage is that the flumes of water help wash loose starch and scrap slicing material off the surfaces of the slices **582**. A second advantage is that water flumes offer a gentle and sanitary medium of transportation. A third advantage is that water flumes can move the slices **582** more quickly than traditional mechanical methods.

The overall dimensions of the slices produced cannot exceed the cross-sectional dimensions of the feed tube **220** where it meets (or comes close to) the slicing wheel **210**. Thus, when the feed tube **220** is perpendicular to the cutting surface, the slices produced will not exceed the diameter of the circular cross-sectional area defined by the bottom end of the feed tube **220**. The slice shapes will tend to be circular with such a

configuration. Note, however, that smaller elongated potatoes may lie in a tilted position within the tube as they are being sliced. The resulting slices may therefore be slightly oblong and larger than the potatoes' minor-dimension diameters, but in no case larger than the diameter of the feed tube **220**. In contrast, larger elongated potatoes will tend to orient themselves in a more substantially vertical position and create slices that are closer in size to the potatoes' minor-dimension diameters. Thus, transversely slicing potatoes in accordance with the present invention produces more consistently-sized slices from a wide range of potato shapes and sizes than slicing potatoes using prior art centrifugal-type slicers.

While the feed tube **220** shown in **Figures 2** and **3** is substantially perpendicular to the slicing wheel, the feed tube **220** can be tilted to vary the shape of the slices. When the feed tube **220** is tilted with respect to a vector perpendicular to the slicing wheel **210** surface, the slices produced may approach the oval cross-sectional area defined by the bottom of the feed tube **220** where it meets or approaches the slicing wheel **210**. Only oblong potatoes or other oblong-shaped foods, however, will produce different slice shapes when the angle of introduction is tilted.

Figures 2 and **3** show only one feed tube **220** for introducing potatoes **230** to the slicing wheel **210**. However, more feed tubes can be used to increase the number of slices **232** produced per revolution of the slicing wheel **210**. The number of slices **232** produced per revolution can also be increased by increasing the number of blades **212** on the slicing wheel **210**.

Figures 4a and **4b** show examples of slices produced when a transverse slicer, such as the one shown in **Figures 2** and 3, is supplied with either a round potato **410** or

an oblong potato **440**. A transverse slicer will slice a round chipping potato **410** into round slices with ridges **430** or without ridges **420**, depending upon whether the slicer's blade edges are corrugated. A transverse slicer will also slice an oblong potato **440** into round slices with or without ridges **460, 450**, depending on whether the blade edges are corrugated. Thus, both round and oblong potatoes **410, 440** can be used in transverse slicers as long as each potato's largest cross-sectional diameter is smaller than the diameter of the slicer's feed tube.

Slice Spreader

Figures 11a and **11b** are respectively a side elevational view and a perspective view of a slice spreader **1100** in accordance with a preferred embodiment of the present invention. The slice spreader **1100** comprises an inverted siphon, which is a pipeline having its end sections above a middle section, and a spreader discharge **1112**. While the term 'inverted siphon' is commonly used in the art, it is somewhat misleading as there is no siphon action involved. In the embodiment shown in **Figures 11a** and **11b**, two post-slicer water flumes carrying potato slices converge at a T-section of the flume piping **1114** where the post-slicer flumes then mix and enter the inverted siphon **1110**. Note that any number of flumes may lead into the spreader, including a single flume, and such flume or flumes can lead into the spreader at various angles. By controlling the distance that the flume or flumes drop before reaching the water level **1124** within the inverted siphon **1110**, the amount of turbulence through the inverted siphon **1110** can be controlled. The degree of turbulence determines the amount of mixing and washing that the slices undergo. Turbulent flow also helps prevent slice clumping. After the flume of

slices and water travels through the base of the u-shaped inverted siphon **1110**, the flume then encounters a fairly sharp 90-degree turn upwards. At the upward turn of the inverted siphon, the piping transitions from circular piping to a fairly shallow but widening vertical channel **1116**. As the flume flows up the vertical channel **1116**, the channel **1116** fans out in width from the circular siphon piping to about the width of the receiving conveyor **1118**, onto which the slices are discharged. By spreading the slice flume through a widening vertical channel **1116** rather than through a widening horizontal channel, significant floor space can be saved. At the top of the vertical channel **1116**, the flume flows through another fairly sharp 90-degree turn into the spreader discharge **1112**, which is below the flume piping **1114** feeding into the inverted siphon **1100**. The spreader discharge **1112** comprises a fairly flat and short channel that is either horizontal or angled slightly downward. If desired, the discharge **1112** can have an adjustable downward-angled lip **1120** at the end for guiding the flume of slices and water onto the receiving conveyor **1118**. The flume piping **1114** and slicer spreader **1100** should comprise a food-grade, sturdy material capable of withstanding operating pressures and flow rates. Acceptable materials include but are not limited to stainless steel, copper, aluminum, other metals or alloys, and PVC or other plastics.

The u-shaped piping of the inverted siphon **1110**, the shallow vertical channel **1116** of the inverted siphon outlet, and the sharp turn leading into the spreader discharge **1112** all help maintain a turbulent flow so that the slices become evenly distributed and do not clump together. If desired, air can be introduced into the vertical channel **1116** of the inverted siphon outlet to help maintain a turbulent flow or induce a more turbulent flow. The outwardly-fanning vertical channel **1116** and the spreader discharge **1112**

cause the flume of slices and water to evenly distribute over the width of the receiving conveyor **1118**. If desired, however, the spreader discharge **1112** can be tilted towards one side of the receiving conveyor **1118** in order to change the distribution of slices. For example, if a greater density of potato slices is desired on the left side of the receiving conveyor **1118**, the left side of the spreader discharge **1112** can be pushed downwards (or the right side pushed upwards), thus tilting the discharge **1112**. This will shift the distribution of slices towards the left side of the conveyor **1118**. **Figure 11c** is a front cross-sectional view of a spreader discharge **1112** at various possible angles of tilt.

Returning to **Figures 11a** and **11b**, the spreader discharge **1112** and lip **1120**, if present, can also comprise a flexible material so that the bottom surface can be flexed upward or downward to affect the distribution of the slices. A curved bottom surface of the spreader discharge **1112** that is convcave when viewed from above (bulging downward), for example, will cause a greater concentration of potato slices to collect in the center of the receiving conveyor **1118**. Conversely, a curved spreader discharge **1112** that is convex when viewed from above (bulging upward) will cause the distribution of slices to shift towards the edges of the receiving conveyor **1118**. **Figure 11d** is a front cross-sectional view of a spreader discharge in concave and convex positions. Returning to **Figures 11a** and **11b**, the spreader discharge **1112** can furthermore be tilted and flexed simultaneously in order to obtain more complex distributions of slice densities across the width of the receiving conveyor **1118**. This is particularly useful in applications where an even distribution does not yield optimal results. Some ovens and fryers, for example, do not apply an even distribution of heat across the width of the feeding conveyor. As will be explained in more detail below, feedback from downstream processing units such

as an oven or fryer can be used to adjust the titling and flexing of the spreader discharge **1112**. The spreader discharge can be tilted and/or flexed by various devices including pneumatic, hydraulic and mechanical devices, servos, levers, and other devices for adjusting position. Furthermore, the spreader discharge can be adjusted by a manually-controlled or an automatically-controlled actuator or positioner.

Slice Dewatering Stage

In a preferred embodiment, the receiving conveyor **1118** shown in **Figures 11a** and **11b** is part of a slice dewatering stage **592** in a slicing system as diagrammed in **Figure 5**. The receiving conveyor **1118** can comprise any passive or active water-pervious material such as fixed hydrosieve screens, wire mesh, chain links, perforated cloth, vibratory conveyor or a wire conveyor. However, the ability of the conveyor **1118** to receive potato slices without damaging them during transport must be considered. Thus, the receiving conveyor **1118** is preferably made of a wire-mesh material. In operation, the water passes through the conveyor **1118** and is collected by an effluent pan **1122**. Some or all of the water, which contains loose starch and other particles, can be sent to a starch removal stage for recycling. Although not preferred, the water can simply be discarded. The potato slices are collected on the receiving conveyor **1118** and conveyed at an incline out of the effluent pan **1122** for further processing.

Starch Removal

Because the slice flume water is laden with starch and particulates released during slicing, some or all of the separated slice flume water **594** is collected from the slice

dewatering stage **592** and sent to a starch removal unit **595** as diagrammed in **Figure 5**. If desired, starch-laden water from other stages, such as the potato-flume dewatering stage **550** or the swirl tank **560**, can also be sent to the starch removal unit **595** for recycling. Various methods can be used to purify the flume water, including centrifugal separation, screening, filtering, and distillation. In a preferred embodiment, some of the starch-laden water is first screened through a hydrosieve to remove large particles and other solids. The remaining starch-laden water is simply recycled back to the slicers and slice flumes. For example, a vibratory mesh screen such as that manufactured by Sweco, L.L.C., or a rotary sieve such as that manufactured by Lyco Manufacturing, Inc., can be used. The hydrosieved water is then pumped to one or more hydrocyclones to further remove starch. It may also be desirable to further process the water through a rotating vacuum drum filter such as that described in U.S. Patent No. 2,576,288, granted to Fink et al. After the starch particles and fines have been filtered from the water, the filtered water can be recycled to any part of the process requiring water, such as the diverter, eductor and slicing stages.

Process Control System

Although the process control system will be described with respect to a preferred embodiment in which potatoes are sliced, the process control system is equally applicable to the slicing of other types of produce (or food items). The process control system described herein also applies to systems for slicing vegetables, tubers, nuts, and fruit. Further, the process control system also applies to systems for cutting and coring food items where quality and/or yield suffers with higher device operating rates.

Figure 12 is a flow diagram of the process control loops used to control the flow of potatoes throughout the system shown in **Figure 5** in accordance with a preferred embodiment of the present invention. For simplicity, **Figure 12** depicts only one diverted flow of potatoes. The same control loops, however, apply to each diverted flow. The mass-flow/spreading conveyor **520**, diverter **530**, and slicer **580** (and slicer infeed conveyor **570**, depending on the method of operation) all have set points **1220, 1218, 1216, 1214** that can be adjusted according to the operating conditions. At startup, each unit is given an initial set point that is set according to predicted operating conditions. These initial set points will remain until a potato feed **502** makes its way through the system, thus enabling downstream process control instruments to produce control feedback.

Once steady state is reached, sensors **1210** positioned over the laning portions of the slicer infeed conveyors **570** (which can be single-conveyor or double-conveyor designs as described above) measure the duty cycles of at least one lane of potatoes leading into each slicer. Depending on the control method, the sensors may also measure individual potato velocities. Various types of sensors can be used including but not limited to optical sensors, laser sensors, Doppler/radar, ultrasonic sensors, and proximity sensors. The term "duty cycle" is defined as the ratio of the combined lengths of the potatoes in a given lane relative to the length of the lane. Thus, a 0.90 duty cycle means that the measured lane is 90% full of potatoes lengthwise, and a 1.00 duty cycle means that the measured lane is completely full lengthwise with no gaps between any potatoes. The velocity and duty cycle information **1212** for the measured lane is used to set the rotational speed **1216** of the corresponding slicer **580**.

If the slicer infeed conveyors **570** are double-conveyor designs in which the spreading and laning portions are separate and can be independently controlled, the relative duty cycles of each lane on the laning portions can be used to adjust how the spreading portions operate. For example, if sensors are positioned over each lane of the laning portion of a double-conveyor design, the duty cycles of each lane can then be measured. By comparing the relative duty cycles of each lane, one can determine if there is an uneven or undesirable distribution of potatoes among the several lanes. If the spreading portion can be adjusted to vary the distribution among the several lanes – such as by tilting or other means – then the relative duty cycle data can be used to adjust the spreading portion. This feedback allows the distribution of potatoes among the lanes to be more closely controlled. However, the addition of another feedback loop also increases the complexity of the entire control system, which may make it more difficult to achieve overall system stability.

In a preferred embodiment, the sensors **1210** positioned over the slicer infeed conveyors **570** are proximity sensors that signal when an object is passing beneath/through them. The on and off signals of one proximity sensor (for example, "on" when an item is passing through, and "off" when there is nothing) can be processed to determine the duty cycle of a given lane. The duty cycle is simply the ratio of the amount of time during the sampling period that the sensor read "on" to the total elapsed time during the sampling period. The information collected by two proximity sensors set at a known distance apart (the "sensor separation length") along a given lane can be processed to determine the velocity of the conveyed objects. As an object passes through each proximity sensor, each sensor's reading changes from "off" to "on." The time lag

between the two sensors' reading changes is measured, and the velocity of the object is calculated by dividing the known sensor separation length by the time lag.

There are several methods for determining the appropriate slicer speeds. The exact method depends upon the type of slicer infeed conveyors **570** used and the manner in which they are operated. Consider, for instance, an embodiment in which each slicer infeed conveyor **570** has a fixed or predetermined conveyor speed. In such an embodiment, the duty cycle **1212** of the conveyor (or one lane upon the conveyor) is measured, and the known conveying speed and duty cycle information is used to calculate the minimum rotational speed **1216** of the corresponding slicer **580**.

In a more preferred embodiment, the velocity of each slicer infeed conveyor **570** is instead adjusted to maintain a constant mass upon the conveyor **570** in order to ensure that the conveyor **570** discharges the same mass flow rate that enters. In such an embodiment, both duty cycles and velocities **1212** are measured, and the information is used to calculate the minimum rotational speed **1216** of the corresponding slicer **580**. A processor, such as a programmable logic controller (PLC), periodically adjusts the mass set point **1214** of the slicer infeed conveyor **570** in order to maintain a desired duty cycle.

The number of slices that can be produced in a given period of time, and thus the length of potatoes that can be cut in a given period of time, depends upon the number of slicers and the revolutions-per-minute (RPM) of the slicers. As previously explained, one of the keys to maximizing yield is to minimize potato-slicing losses by minimizing the cutting blade speed. Yield can be maximized by operating each slicer at reduced speed (compared to prior art centrifugal slicer speeds) and by using as many slicers as are necessary to process a desired flow rate. This method results in fewer losses than running

a single slicer at high speeds. Where the number of slicers is predetermined, cutting efficiency similarly can be increased by running each slicer at or slightly above the necessary cutting velocity. Thus, in a preferred embodiment, the RPM set point **1216** of each slicer **580** is adjusted to the minimum rate necessary to process the potato flow rate (overall potato length per unit of time) measured by the sensors **1210**.

In embodiments where the conveying speed of the slicer infeed conveyor **570** varies, the minimum RPM necessary to process a given flow rate of potatoes is derived by first calculating the overall potato velocity (total length of potatoes to be cut per time, e.g. meters / minute) (V_o) using the duty cycle (DC) and the individual potato velocities (V_i) (in meters per minute, for example) measured by the sensors **1210**. Then the minimum RPM (RPM_{min}) will depend upon the properties of the slicer **580**, i.e. the thickness of each resulting slice (T) (in meters, for example) and the number of slices produced per revolution (N):

$$V_o = V_i * DC$$

$$RPM_{min} = V_o * (1/T) * (1/N)$$

The measured duty cycle is periodically used to adjust the mass set point of the infeed conveyor **570** in order to achieve the desired potato density.

In embodiments where the slicer infeed conveyor **570** is operated at a constant/predetermined conveying velocity, the minimum RPM necessary to process a given flow rate of potatoes is derived by first calculating the overall potato velocity (total length of potatoes to be cut per time, e.g. meters / minute) (V_o) using the duty cycle (DC) measured by the sensors **1210** and the predetermined conveying velocity (V_c, in meters / minute, for example). Then the minimum RPM (RPM_{min}) will depend upon the

properties of the slicer **580**, i.e. the thickness of each resulting slice (T) (in meters, for example) and the number of slices produced per revolution (N):

$$V_o = V_c \ * DC$$

$$RPM_{min} = V_o * (1/T) * (1/N)$$

By setting the RPM **1216** of each slicer **580** in this manner, each potato being sliced will be nearly completely sliced, or will have just finished being sliced, as the next potato (from the same lane and traveling down the same feed tube) approaches the blades of the slicer **580**.

It is possible to have the sensors **1210** monitor only one lane if each slicer-feeding lane has similar overall potato velocities. If desired, the RPM **1216** can also be set slightly higher than the calculated minimum RPM. Over time, an average of the calculated minimum RPM measurements can be determined, and the slicers can be set to run at a predetermined ratio of the average except in circumstances where the actual minimum RPM exceeds the predetermined ratio. This manner of operation allows the slicers to be operated with less variation in rotational velocity, and it also helps avoid plugging the slicers **580** or the slicer feed tubes. For example, the operating RPM ("$RPM_{operating}$") can be set in the following manner:

$RPM_{operating} = (RPM_{average} + X\sigma)$ or (RPM_{min}), whichever is greater,

wherein "$RPM_{average}$" is the average calculated minimum RPM, "X" is a multiplying factor, and "σ" is the standard deviation of the calculated minimum RPM data. In a preferred embodiment, "X" ranges from about 0.5 to about 2.0, which means that the slicers are generally operated at about 0.5 to about 2.0 standard deviations above the average minimum rotational velocity.

In a preferred embodiment, the sensors **1210** monitor each lane of the slicer infeed conveyor **570**. Also, the slicer RPM **1216** is determined using the largest duty cycle of the lanes entering the slicer **580**, assuming each lane has similar individual potato velocities. This ensures that the slicer blades are rotating fast enough to process every lane of potatoes.

Although potato flows having consistent potato sizes and steady flows would result in steady slicer speeds, variations in potato sizes can cause fluctuations in potato velocities. For example, in a preferred embodiment, the slicer infeed conveyor **570** has load cells and regulates the mass flow rate of potatoes by varying its speed in order to improve the performance of mass-sensitive downstream units such as a fryer. Thus, a group of smaller potatoes will require a faster linear velocity than a group of larger potatoes in order to maintain the same mass flow rate.

In addition to using the sensor data **1212** to adjust the slicer cutting speed **1216**, the sensor data **1212** can also be used to maintain an average desired gap between potatoes along the lanes of each slicer infeed conveyor **570**. Maintaining a gap between potatoes in each lane helps prevent jamming of the feed tubes and slicers **580**. Because the duty cycle (DC) indicates the amount of space present between potatoes, the duty cycle can be used to adjust the mass set point **1214** of the slicer infeed conveyor **570**. For example, if the duty cycle is too low, the mass set point **1214** of a slicer infeed conveyor **570** equipped with load cells will be increased to accumulate more potatoes. If the duty cycle is too high – close to 1.00 for example – this means that the potatoes in each lane are too close to each other. When the potatoes are too close to each other, undesirable doubling (where potatoes are no longer in single file) may occur, thus increasing the risk

of plugging. The mass set point **1214** of the slicer infeed conveyor **570** will then be decreased in order to increase the gaps between potatoes. The duty cycle measurements can also help detect lane, feed tube or slicer jamming. If the duty cycle for a given lane remains 1.00 even after the mass set point **1214** is adjusted, that particular lane (or downstream feed tube or slicer) is probably jammed. In an automated system, the system can be programmed to alert an operator of a possible jam.

An alternative approach to operating the slicers **580** is to flood the feed tubes of each slicer **580** with potatoes so that there are no gaps between potatoes during slicing. A flooded feed allows an even slower cutting blade speed than that of a spaced feed for a given rate of output. A flooded feed, however, can increase the risk of plugging. It can also reduce slice quality and increase the amount of slicing scrap.

If the slicers **580** are operating at significantly different cutting speeds, this means that the slicers **580** are under significantly different slicing loads. Using the relative rotational speeds **1218** of the slicers, the movable diverters of the diverter stage **530** can be adjusted to change the distribution of potatoes among the slicers **580** and more evenly distribute the slicing loads. For example, if one slicer **580** is operating at a much higher RPM than the other slicers, the diverters **530** can be shifted to reduce the amount of potatoes diverted to the overworked slicer **580** and increase the amount of potatoes diverted to the other slicers **580**.

Once the potatoes have been sliced, dewatered, and have been conveyed downstream for further processing, feedback from downstream units can be used to adjust how the slice spreader **590** distributes slices onto the dewatering conveyor of the slice dewatering stage **592**. One of the benefits of using a slice spreader in accordance

with the present invention is that such a slice spreader has two degrees of freedom in its control. More specifically, the left-to-right distribution and the inner/outer distribution of slices onto the dewatering conveyor are independently controllable. Furthermore, such a slice spreader is scaleable to any size. Assume, for example, that the dewatering conveyor leads slices through a downstream fryer, and the fryer is applying more energy to the middle of the conveyor than at the edge of the conveyor, thereby overcooking the slices in the middle and undercooking the slices at the edges. The slice spreader **590** can be directed to distribute more slices to the middle and fewer slices to the edges of the dewatering conveyor. Such an adjustment to the slice spreader will help make the downstream cooking/frying more consistent. Assume further that, in addition to applying more energy to the middle of the conveyor than at the edges/sides, the fryer also periodically experiences a temporary increase in energy to the right side and a decrease in energy to the left side due to unforeseen circumstances. In such a case, the slice spreader **590** can simply be tilted to the right whenever the fryer experiences a shift in energy to the right side, thus directing more slices to the right side. The slice spreader **590** can be returned to its previous position when the shift in energy disappears. Note that the slice spreader's convex/concave setting need not be altered when adjusting for such a left/right shift.

The mass-flow/spreading conveyor **520** (and inclined metering conveyor, if any) can also be programmed to respond to operating conditions further downstream, such as in an oven or frying stage. If a downstream fryer or oven is being overworked, for example, feedback **1220** from the downstream unit can be used to reduce the flow rate of potatoes **512** through the mass-flow/spreading conveyor **520**.

In an automated system, the process control measurements and changes can be controlled using one or more programmable logic controllers (PLC), computers, or other automated devices. However, operators can also manually perform the set point changes and data interpretation discussed above.

Although the food processing system and process control system have been described with respect to slicing potatoes, the food processing system and process control system also apply to slicing other food items including fruits, vegetables, other tubers. Further, the process control system also applies to systems for cutting and coring food items where quality and/or yield suffers with higher device operating rates.

While the invention has been particularly shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention.